ARTICLE OF APPAREL INCORPORATING A MODIFIABLE TEXTILE STRUCTURE

BACKGROUND OF THE INVENTION

Field of the Invention

[01] The present invention relates to apparel. The invention concerns, more particularly, an article of apparel that incorporates a textile with a structure that changes or is otherwise modified by a physical stimulus, such as the presence of water, to modify a property of the textile. The invention has application, for example, to articles of apparel intended for use during athletic activities.

Description of Background Art

[02] Articles of apparel designed for use during athletic activities generally exhibit characteristics that enhance the performance or comfort of an individual. For example, apparel may incorporate an elastic textile that provides a relatively tight fit, thereby imparting the individual with a lower profile that minimizes wind resistance. Apparel may also be formed from a textile that wicks moisture away from the individual in order to reduce the quantity of perspiration that accumulates adjacent to the skin. Furthermore, apparel may incorporate materials that are specifically selected for particular environmental conditions.

[03] The characteristics of the textiles that are incorporated into apparel are generally selected based upon the specific activity for which the apparel is intended to be used. A textile that minimizes wind resistance, for example, may be suitable for activities where speed is a primary concern. Similarly, a textile that reduces the quantity of perspiration that accumulates adjacent to the skin may be most appropriate for athletic activities commonly associated with a relatively high degree of exertion. Accordingly, textiles may be selected to enhance the performance or comfort of individuals engaged in specific athletic activities.

[04] Textiles may be defined as any manufacture from fibers, filaments, or yarns characterized by flexibility, fineness, and a high ratio of length to thickness. Textiles generally fall into

two categories. The first category includes textiles produced directly from webs of fibers by bonding, fusing, or interlocking to construct non-woven fabrics and felts. The second category includes textiles formed through a mechanical manipulation of yarn, thereby producing a woven fabric.

[05] Yarn is the raw material utilized to form textiles in the second category and may be defined as an assembly having a substantial length and relatively small cross-section that is formed from at least one filament or a plurality of fibers. Fibers have a relatively short length and require spinning or twisting processes to produce a yarn of suitable length for use in textiles. Common examples of fibers are cotton and wool. Filaments, however, have an indefinite length and may merely be combined with other filaments to produce a yarn suitable for use in textiles. Modern filaments include a plurality of synthetic materials such as rayon, nylon, polyester, and polyacrylic, with silk being the primary, naturally-occurring exception. Yarn may be formed from a single filament or a plurality of individual filaments grouped together. Yarn may also include separate filaments formed from different materials, or the yarn may include filaments that are each formed from two or more different materials. Similar concepts also apply to yarns formed from fibers. Accordingly, yarns may have a variety of configurations that generally conform to the definition provided above.

[06] The various techniques for mechanically manipulating yarn into a textile include interweaving, intertwining and twisting, and interlooping. Interweaving is the intersection of two yarns that cross and interweave at substantially right angles to each other. The yarns utilized in interweaving are conventionally referred to as warp and weft. Intertwining and twisting encompasses procedures such as braiding and knotting where yarns intertwine with each other to form a textile. Interlooping involves the formation of a plurality of columns of intermeshed loops, with knitting being the most common method of interlooping.

SUMMARY OF THE INVENTION

[07] The present invention is an article of apparel that includes a textile with at least one property that changes upon exposure to a physical stimulus. The textile has a modifiable structure formed from yarns that exhibit a dimensional-transformation upon exposure to the physical stimulus. The yarns have a first set of dimensions when unexposed to the physical stimulus, and the yarns have a second set of dimensions when exposed to the physical stimulus. The structure of the textile is modified by exposing the textile to the physical stimulus such that the yarns transform from the first set of dimensions to the second set of dimensions and change the property of the textile. The yarns may be formed from a material that exhibits the dimensional-transformation upon exposure to water. Accordingly, the physical stimulus may be water. In some embodiments, the physical stimulus may also be heat, light, or moving air, for example.

[08] The textile may be formed through an interweaving process wherein the yarns define openings in the textile. The openings exhibit a first area when the yarns are unexposed to the physical stimulus, and the openings exhibit a second area when the yarns are exposed to the physical stimulus. The area of the openings may determine, for example the permeability of the textile. Accordingly, when the first area is greater than the second area, the permeability of the textile is decreased upon exposure to the physical stimulus. Furthermore, when the first area is less than the second area, the permeability of the textile is increased upon exposure to the physical stimulus. In some embodiments, the yarns may exhibit an undulating configuration to increase the permeability upon exposure to the physical stimulus.

[09] A substantial portion of the textile may be formed from the yarn. Alternately, a first portion of the yarns may exhibit the dimensional-transformation upon exposure to the physical stimulus, and a second portion of the yarns may remain dimensionally-stable upon exposure to the physical stimulus.

[10] The textile may also be formed through an interlooping process. In some embodiments, the yarns define openings in the textile. The openings may exhibit a first area when the yarns are unexposed to the physical stimulus, and the openings may exhibit a second area

when the yarns are exposed to the physical stimulus, thereby affecting the permeability of the textile. In other embodiments, the structure of the textile may exhibit a first texture when the yarns are unexposed to the physical stimulus, and the structure of the textile may exhibit a second texture when the yarns are exposed to the physical stimulus. The first texture may be, for example, smoother than the second texture, and the second texture may include a plurality of nodes that extend outward from a surface of the textile.

[11] The advantages and features of novelty characterizing the present invention are pointed out with particularity in the appended claims. To gain an improved understanding of the advantages and features of novelty, however, reference may be made to the following descriptive matter and accompanying drawings that describe and illustrate various embodiments and concepts related to the invention.

DESCRIPTION OF THE DRAWINGS

[12] The foregoing Summary of the Invention, as well as the following Detailed Description of the Invention, will be better understood when read in conjunction with the accompanying drawings.

[13] Figure 1 is a plan view of an article of apparel incorporating a first textile structure in accordance with the present invention.

[14] Figure 2 is a plan view of a portion of the first textile structure in an unexposed state.

[15] Figure 3 is a plan view of the portion of the first textile structure in an exposed state.

[16] Figure 4 is a plan view of a portion of a second textile structure in an unexposed state.

[17] Figure 5 is a plan view of the portion of the second textile structure in an exposed state.

[18] Figure 6 is a plan view of a portion of a third textile structure in an unexposed state.

[19] Figure 7 is a plan view of the portion of the third textile structure in an exposed state.

[20] Figure 8 is a plan view of a portion of a fourth textile structure in an unexposed state.

[21] Figure 9 is a plan view of the portion of the fourth textile structure in an exposed state.

[22] Figure 10 is a plan view of a portion of a fifth textile structure in an unexposed state.

[23] Figure 11 is a plan view of the portion of the fifth textile structure in an exposed state.

[24] Figure 12 is a plan view of a portion of a sixth textile structure in an unexposed state.

[25] Figure 13 is a schematic plan view of a larger portion of the sixth textile structure in the unexposed state.

[26] Figure 14 is a plan view of the portion of the sixth textile structure in an exposed state.

[27] Figure 15 is a schematic plan view of the larger portion of the sixth textile structure in the exposed state.

DETAILED DESCRIPTION OF THE INVENTION

Introduction

[28] The following discussion and accompanying figures disclose an article of apparel 10 in accordance with the present invention. Apparel 10 is depicted in Figure 1 as having the general configuration of a conventional short-sleeved shirt. One skilled in the relevant art will recognize, however, that the various textiles disclosed in the following material may be incorporated into articles of apparel exhibiting a variety of configurations, including long-sleeved shirts, headwear, coats, jackets, pants, underwear, gloves, socks, and footwear, for example. Accordingly, the various concepts disclosed in the following discussion and accompanying figures with respect to apparel 10 may be utilized in connection with a variety of apparel configurations.

[29] The primary elements of apparel 10 include a torso portion 11 and two arm portions 12a and 12b. Torso portion 11 corresponds with a torso of an individual and, therefore, covers the torso when worn. Similarly, arm portions 12a and 12b respectively correspond with a right arm and a left arm of the individual and cover the arms when worn. Apparel 10 exhibits, therefore, the general configuration of a conventional long-

sleeved shirt. In contrast with the conventional long-sleeved shirt, however, apparel 10 is at least partially formed from a textile with a structure that is modified by a physical stimulus, thereby changing properties of the textile. For example, the permeability or texture of the textiles may change when exposed to water, increased temperature, or moving air (i.e., wind). Accordingly, the structures of the textiles may be modified in order to provide apparel 10 with different properties. The following material discloses a variety of textiles with a structure that is modified by a physical stimulus in order to change the properties of the textile or apparel 10.

First Textile Structure

[30] A portion of a textile 20 that is suitable for apparel 10 is disclosed in Figures 2 and 3. Textile 20 has the structure of an interwoven material that includes a plurality of weft yarns 21 and a plurality of warp yarns 22. Textile 20 may be formed, therefore, by mechanically manipulating yarns 21 and 22 thorough an interweaving process, which involves crossing and interweaving yarns 21 and 22 at substantially right angles to each other. The process of crossing and interweaving yarns 21 and 22 at substantially right angles to each other forms a plurality of discrete openings 23 that are located between the various yarns 21 and 22.

[31] Each of yarns 21 and 22 are formed from one or more filaments or fibers that experience a dimensional-transformation when exposed to a specific physical stimulus. In other words, the dimensions (i.e., length and thickness, for example) of yarns 21 and 22 change when textile 20 is in the presence of the physical stimulus. The dimensional-transformation of yarns 21 and 22 has an effect upon the structure of textile 20. More particularly, the dimensional-transformation of yarns 21 and 22 modifies the structure of textile 20, thereby changing the properties of textile 20. Accordingly, exposing textile 20 to the physical stimulus has the effect of changing the properties of textile 20, thereby changing the properties of apparel 10.

[32] The manner in which exposing textile 20 to a physical stimulus has an effect upon the properties of textile 20 will now be discussed. With reference to Figure 2, textile 20 is depicted in an unexposed state, in which yarns 21 and 22 are not exposed to the physical

stimulus. With reference to Figure 3, however, textile 20 is depicted in an exposed state, in which yarns 21 and 22 are exposed to the physical stimulus. In the unexposed state, yarns 21 and 22 exhibit dimensions with a relatively narrow thickness such that the area of each opening 23 is relatively large. In the exposed state, however, yarns 21 and 22 exhibit a greater thickness, which decreases the area of each opening 23. That is, exposing yarns 21 and 22 to the physical stimulus causes yarns 21 and 22 to increase in thickness, which decreases the area of each opening 23 and modifies the structure of textile 20.

[33] The modification in the structure of textile 20 (i.e., decreasing the area of openings 23) changes the properties of textile 20. In the unexposed state, each opening 23 is relatively large. In the exposed state, however, the area of each opening 23 is decreased, which decreases the overall permeability of textile 20 to water, light, and moving air, for example. That is, the smaller area of each opening 23 in the exposed state decreases the ease with which water, light, and moving air may penetrate or otherwise extend through textile 20. Accordingly, exposing textile 20 to a physical stimulus changes the permeability properties of textile 20, thereby changing the permeability properties of apparel 10.

[34] Various physical stimuli may induce a dimensional-transformation of yarns 21 and 22, including the presence of water (whether in a liquid or gaseous state), increased temperature, or moving air, for example. With regard to water, many materials exhibit a tendency to absorb water and swell or otherwise transform dimensionally. The dimensional-transformation may occur relatively rapidly due to immersion or contact with liquid water. In addition, the dimensional-transformation may occur relatively slowly due to a prolonged exposure to air with a relative humidity that is greater than 75 percent, for example. Textile 20, and particularly yarns 21 and 22, may be formed from one or more of these materials that exhibit a tendency to transform dimensionally in the presence of a physical stimulus such as water. Furthermore, yarns 21 and 22 may be formed from materials that transform dimensionally due to temperature increases or moving air.

[35] Yarns 21 and 22, as discussed above, may be formed from a variety of materials that transform dimensionally in the presence of water. For example, at least a portion of the filaments or fibers in yarns 21 and 22 may be formed of a moisture-absorptive polyester material, such as the various moisture-absorptive polyester materials manufactured by Tejin Fibers Limited of Japan. In some embodiments, yarns 21 and 22 may be a 75 denier, 72 filament semi-dull textured polyester yarn, and suitable formulations for the fiber or filament contents of yarns 21 and 22 include: (i) 70 percent generally non-absorptive polyester and 30 percent moisture-absorptive polyester; (ii) 76 percent generally non-absorptive polyester and 24 percent moisture-absorptive polyester; (iii) 80 percent generally non-absorptive polyester and 20 percent moisture-absorptive polyester; or (iv) 84 percent cationic-dyeable polyester that is also generally non-absorptive and 16 percent moisture-absorptive polyester. Accordingly, the percentage of the fibers or filaments formed from moisture-absorptive polyester may vary considerably within the scope of the present invention, and may also range from 5 percent to 100 percent in some embodiments. In each of the examples above, a non-absorptive or otherwise dimensionally-stable polyester fibers or filaments are combined with a moisture-absorptive polyester fibers or filaments. Other non-absorptive polymer fibers or filaments may also be utilized, such as rayon, nylon, and polyacrylic. In addition, silk, cotton, or wool may be utilized in yarns 21 and 22. Accordingly, a wide range of materials are suitable for the various yarns 21 and 22.

[36] When incorporated into article of apparel 10, textile 20 may be utilized to protect or otherwise insulate the individual from specific environmental conditions. As discussed above, one physical stimulus that induces a dimensional-transformation in yarns 21 and 22 is water, such as rain. When rain or another source of water (i.e., the physical stimulus) is not present, textile 20 is in the unexposed state and exhibits a relatively high permeability that permits air to freely enter and exit apparel 10, thereby cooling the individual. When significant quantities of water contact apparel 10, thereby placing textile 20 in the exposed state, textile 20 exhibits a relatively low permeability that inhibits the movement of water through textile 20. More specifically, water in the form of rain that contacts apparel 10 will cause openings 23 to decrease in area and limit the quantity of water that enters apparel 10. When yarns 21 and 22 are formed from a

material that transforms dimensionally in the presence of heat, sunlight or other heat sources induce openings 23 to decrease in area and limit the quantity of solar radiation that enters apparel 10. In addition, moving air in the form of wind may induce openings 23 to decrease in area to limit the quantity of air that passes through apparel 10. Accordingly, forming textile 20 from yarns 21 and 22 that transform dimensionally in the presence of one or more physical stimuli may be utilized to effectively insulate the individual from specific environmental conditions, such as rain, sunlight, or wind.

[37] Based upon the above discussion, textile 20 may be formed from various yarns 21 and 22 that transform dimensionally in the presence of a physical stimulus. The dimensional-transformation of yarns 21 and 22 modify the structure of textile 20, thereby inducing a change in the properties of textile 20. When incorporated into apparel 10, the change in the properties of textile 20 when exposed to the physical stimulus may be utilized to insulate the individual from specific environmental conditions, such as rain, sunlight, or wind. Accordingly, textile 20 effectively adapts to changing environmental conditions in order to enhance the comfort of the individual wearing apparel 10.

Second Textile Structure

[38] With respect to textile 20, both of yarns 21 and 22 are at least partially formed from materials that transform dimensionally in the presence of a physical stimulus. In some embodiments, however, various yarns may be entirely formed from a material that does not dimensionally transform to a significant degree in the presence of a physical stimulus. That is, some of the yarns forming the textile of apparel 10 may be formed from a dimensionally-stable yarn that is not significantly affected by the physical stimulus.

[39] A textile 30 is depicted in Figures 4 and 5 that includes a plurality of weft yarns 31a, a plurality of other weft yarns 31b, a plurality of warp yarns 32a, and a plurality of other warp yarns 32b that define various openings 33. Whereas yarns 31a and 32a are formed from a material that dimensionally transforms in the presence of a physical stimulus, yarns 31b and 32b are formed from a dimensionally-stable yarn that is not significantly affected by the physical stimulus.

[40] The manner in which exposing textile 30 to a physical stimulus has an effect upon the properties of textile 30 will now be discussed. With reference to Figure 4, textile 30 is depicted in an unexposed state, in which yarns 31a, 31b, 32a, and 32b are not exposed to the physical stimulus. With reference to Figure 5, however, textile 30 is depicted in an exposed state, in which yarns 31a, 31b, 32a, and 32b are exposed to the physical stimulus. In the unexposed state, each of yarns 31a, 31b, 32a, and 32b exhibit dimensions with a relatively narrow thickness such that the area of each opening 33 is relatively large. In the exposed state, however, yarns 31a and 32a exhibit a greater thickness, which decreases the area of each opening 33. That is, exposing yarns 31a and 32a to the physical stimulus causes yarns 31a and 32a to increase in thickness, which decreases the area of each opening 33 and modifies the structure of textile 30. As discussed above, yarns 31b and 32b are formed from a dimensionally-stable yarn that is not significantly affected by the physical stimulus. Accordingly, 31b and 32b do not transform dimensionally when exposed to the physical stimulus.

[41] The modification in the structure of textile 30 (i.e., decreasing the area of openings 33) changes the properties of textile 30. In the unexposed state, each opening 33 is relatively large. In the exposed state, however, the area of each opening 33 is decreased, which decreases the overall permeability of textile 30 to water, light, and moving air, for example. That is, the smaller area of each opening 33 in the exposed state decreases the ease with which water, light, and moving air may penetrate through textile 30. Accordingly, exposing textile 30 to a physical stimulus changes the permeability properties of textile 30. Given that textile 30 may replace textile 20 in apparel 10, exposing textile 30 to a physical stimulus may be utilized to effectively change the permeability properties of apparel 10.

[42] An advantage of forming yarns 31b and 32b from a dimensionally-stable yarn that is not significantly affected by the physical stimulus relates to the dimensional stability of textile 30. Yarns 31b and 32b form a web in textile 30 that does not significantly change dimensions when exposed to the physical stimulus. Whereas yarns 31a and 32a transform dimensionally, yarns 31b and 32b remain dimensionally-stable (i.e., in their original dimensions). Accordingly, yarns 31b and 32b may be utilized to ensure that the

shape and dimensions of textile 30 are retained, despite the dimensional-transformation of yarns 31a and 32a.

Third Textile Structure

[43] Another potential configuration for the textile that forms at least a portion of apparel 10 is disclosed in Figures 6 and 7, in which a plurality of weft yarns 41 and a plurality of warp yarns 42 define various openings 43. Whereas weft yarns 41 are formed from a material that dimensionally transforms in the presence of a physical stimulus, warp yarns 42 are formed from a dimensionally-stable yarn that is not significantly affected by the physical stimulus. Accordingly, weft yarns 41 do not substantially change dimensions when exposed to the physical stimulus.

[44] Exposing textile 40 to a physical stimulus modifies the structure of textile 40, which has an effect upon the properties of textile 40. With reference to Figure 6, textile 40 is depicted in an unexposed state, in which yarns 41 and 42 are not exposed to the physical stimulus. With reference to Figure 7, however, textile 40 is depicted in an exposed state, in which yarns 41 and 42 are exposed to the physical stimulus. As with textiles 20 and 30, exposing yarns 41 and 42 to the physical stimulus causes yarns 41 to increase in thickness, which decreases the area of each opening 43 and modifies the structure of textile 40. The modification in the structure of textile 40 (i.e., decreasing the area of openings 43) changes the properties of textile 40. In the unexposed state, each opening 33 is relatively large. In the exposed state, however, the area of each opening 33 is decreased, which decreases the overall permeability of textile 30 to water, light, and moving air, for example. Given that textile 40 may replace textile 20 in apparel 10, exposing textile 40 to a physical stimulus may be utilized to effectively change the permeability properties of apparel 10. As with textile 30, forming warp yarns 42 from a dimensionally-stable yarn that is not significantly affected by the physical stimulus ensures that the shape and dimensions of textile 40 are retained, despite the dimensional-transformation of weft yarns 41.

Fourth Textile Structure

[45] The configurations of textiles 20, 30, and 40 may be utilized to protect or otherwise insulate the individual from specific environmental conditions. As discussed above, the dimensional-transformation of various yarns induces the openings between the yarns to decrease in area. The decrease in area decreases the permeability of textiles 20, 30, and 40, thereby permitting less rain, sunlight, or wind to enter apparel 10. It may be desirable in some situations, however, to increase the permeability of the textile forming apparel 10. For example, increasing the permeability may be utilized to increase air flow through the textile forming apparel 10, thereby enhancing the removal of perspiration from the individual.

[46] A textile 50 with the structure of an interwoven material that includes a plurality of weft yarns 51, a plurality of warp yarns 52a, and a plurality of warp yarns 52b is depicted in Figures 8 and 9. Textile 50 may be formed, therefore, by mechanically manipulating yarns 51, 52a, and 52b thorough an interweaving process, which involves crossing and interweaving weft yarns 51 at substantially right angles to yarns 52a and 52b. The process of crossing and interweaving weft yarns 51 at substantially right angles to yarns 52a and 52b forms a plurality of discrete openings 53.

[47] Whereas yarns 52a are formed from a material that dimensionally transforms in the presence of a physical stimulus, yarns 51 and 52b are formed from a dimensionally-stable yarn that is not significantly affected by the physical stimulus. In addition, warp yarns 52a exhibit an undulating or otherwise wavy configuration, whereas yarns 51 and 52b are relatively straight.

[48] The manner in which exposing textile 50 to a physical stimulus has an effect upon the properties of textile 50 will now be discussed. With reference to Figure 8, textile 50 is depicted in an unexposed state, in which yarns 51, 52a, and 52b are not exposed to the physical stimulus. With reference to Figure 9, however, textile 50 is depicted in an exposed state, in which yarns 51, 52a, and 52b are exposed to the physical stimulus. In the unexposed state, yarns 51, 52a, and 52b exhibit dimensions with a relatively narrow thickness such that the area of each opening 53 is relatively small. In the exposed state,

however, warp yarns 52a exhibit a greater thickness and a greater degree of undulation, which increases the area of each opening 53. That is, exposing yarns 51, 52a, and 52b to the physical stimulus causes warp yarns 52a to increase in thickness and degree of undulation, which increases the area of each opening 53 and modifies the structure of textile 50.

[49] The modification in the structure of textile 50 (i.e., increasing the area of openings 53) changes the properties of textile 50. In the unexposed state, each opening 53 is relatively small. In the exposed state, however, the area of each opening 53 is increased, which increases the overall permeability of textile 50 to water, light, and moving air, for example. That is, the greater area of each opening 53 in the exposed state increases the ease with which water, light, and moving air may penetrate through textile 50. Accordingly, exposing textile 50 to a physical stimulus increases the permeability properties of textile 50, thereby increasing the permeability properties of apparel 10.

[50] When incorporated into article of apparel 10, textile 50 may be utilized to cool the individual and remove perspiration from the individual, for example. Based upon the above discussion, therefore, textile 50 may be formed from various warp yarns 52a that transform dimensionally and in degree of undulation in the presence of a physical stimulus. The dimensional-transformation of warp yarns 52a modifies the structure of textile 50, thereby inducing a change in the properties of textile 50. When incorporated into apparel 10, the change in the properties of textile 50 when exposed to the physical stimulus may be utilized to cool the individual and remove perspiration from the individual. Accordingly, textile 50 effectively adapts to changing perspiration levels of the individual in order to enhance the comfort of the individual wearing apparel 10.

Fifth Textile Structure

[51] Each of textiles 20, 30, 40, and 50 are formed thorough an interweaving process, which involves crossing and interweaving weft yarns and warp yarns at substantially right angles to each other. A textile that adapts to changing perspiration levels of the individual, for example, in order to enhance the comfort of the individual may also be formed through other methods of mechanically-manipulating yarns. Referring to Figures

10 and 11, a textile 60 that is formed through an interlooping process is disclosed. Interlooping involves the formation of a plurality of columns of intermeshed loops, with knitting being the most common method of interlooping. Textile 60 includes a plurality of courses (i.e., a row of needle loops produced by adjacent needles during the knitting cycle) and a plurality of wales (i.e., a column of intermeshed needle loops generally produced by the same needle the knits at successive knitting cycles) that are formed from a yarn 61.

[52] Yarn 61 is formed from a material that dimensionally transforms in the presence of a physical stimulus. More particularly, the dimensions of yarn 61 (i.e., length and thickness, for example) may increase in the presence of the physical stimulus. When exposed to a physical stimulus, yarn 61 dimensionally-transforms in both length and thickness. Although an increase thickness would appear to decrease the area of each opening 62, the associated increase in length separates the various portions of yarn 61 to a greater degree and actually increases the area of each opening 63. That is, the increase in thickness has a greater effect upon the area of openings 63 than the increase in thickness, thereby increasing the overall area of each opening 63. When exposed to the physical stimulus, therefore, the permeability of textile 60 may increase.

[53] The manner in which exposing textile 60 to a physical stimulus has an effect upon the properties of textile 60 will now be discussed in greater detail. With reference to Figure 10, textile 60 is depicted in an unexposed state, in which yarn 61 is not exposed to the physical stimulus. With reference to Figure 11, however, textile 60 is depicted in an exposed state, in which yarn 61 is exposed to the physical stimulus. In the unexposed state, the area of each opening 63 is relatively small. In the exposed state, however, yarn 61 exhibits a greater thickness and a greater length. As discussed above, the increase in length dominates the increase in thickness in order to increase the overall area of each opening 63. That is, exposing yarn 60 to the physical stimulus causes yarn 60 to increase in length, which increases the area of each opening 63 and modifies the structure of textile 60.

[54] The modification in the structure of textile 60 (i.e., increasing the area of openings 63) changes the properties of textile 60. In the unexposed state, each opening 63 is relatively small. In the exposed state, however, the area of each opening 63 is increased, which increases the overall permeability of textile 60 to water, light, and moving air, for example. That is, the greater area of each opening 63 in the exposed state increases the ease with which water, light, and moving air may penetrate through textile 60. Accordingly, exposing textile 60 to a physical stimulus increases the permeability properties of textile 60, thereby increasing the permeability properties of apparel 10.

[55] When incorporated into article of apparel 10, textile 60 may be utilized to cool the individual and remove perspiration from the individual, for example. Based upon the above discussion, therefore, textile 60 may be formed from yarn 61, which transforms dimensionally and in degree of undulation in the presence of a physical stimulus. The dimensional-transformation of yarn 61 modifies the structure of textile 60, thereby inducing a change in the properties of textile 60. When incorporated into apparel 10, the change in the properties of textile 60 when exposed to the physical stimulus may be utilized to cool the individual and remove perspiration from the individual. Accordingly, textile 60 effectively adapts to changing perspiration levels of the individual in order to enhance the comfort of the individual wearing apparel 10.

Sixth Textile Structure

[56] Increasing or decreasing the area of openings between the various yarns that form a textile is one manner in which the structure of the textile may be modified in order to change the properties (i.e., permeability) of the textile. In some embodiments, the texture of the textile may also be modified in order to change the properties of the textile. Referring to Figures 12-15, a textile 70 is disclosed. Textile 70 is formed from a yarn 71 and a yarn 72 through an interlooping process. As will be described in greater detail below, the texture of textile 70 changes from being relatively smooth to having a plurality of nodes 73 that form a separation between the individual and textile 70. Nodes 73 effectively hold textile 70 away from the individual and permit air to flow between textile 70 and the individual, thereby increasing removal of perspiration. In order to form textile

70, yarns 71 and 72 are mechanically-manipulated through a circular knitting process to form textile 70 with a double knit structure. In some embodiments, three or more yarns may be utilized to form textile 70, and a variety of other knit structures in addition to the double knit structure may be utilized.

[57] Whereas yarn 71 is formed from a material that dimensionally transforms in the presence of a physical stimulus, yarn 72 is formed from a dimensionally-stable yarn that is not significantly affected by the physical stimulus. Accordingly, yarn 71 substantially changes dimensions when exposed to the physical stimulus. Yarn 71 extends through the structure formed by yarn 72 and is primarily positioned on one side of textile 70. That is, the position of yarn 71 is concentrated on one side of textile 70. When exposed to the physical stimulus, yarn 71 transforms dimensionally, whereas yarn 72 remains dimensionally-stable. The dimensions of yarn 71 increase when exposed to the physical stimulus and form a plurality of nodes 73 on one side of textile 70. That is, the concentrated areas of yarn 71 expand when exposed to the physical stimulus and form nodes 73.

[58] With reference to Figure 12 and 13, textile 70 is depicted in an unexposed state, in which yarns 71 and 72 are not exposed to the physical stimulus. With reference to Figures 14 and 15, however, textile 70 is depicted in an exposed state, in which yarns 71 and 72 are exposed to the physical stimulus. In the unexposed state, textile 70 exhibits a relatively smooth texture. In the exposed state, however, textile 70 exhibits greater texture due to the presence of the plurality of nodes 73. That is, exposing yarn 71 to the physical stimulus forms nodes 73 on one side of textile 70 and causes textile 70 to increase in texture, which modifies the structure of textile 70.

[59] The modification in the structure of textile 70 changes the properties of textile 70. In the unexposed state, textile 70 is relatively smooth and significantly contacts the individual. In the exposed state, however, the texture of textile 70 is increased through the formation of nodes 73, which forms a separation between the individual and textile 70. That is, nodes 73 effectively hold textile 70 away from the individual and permit air to flow between textile 70 and the individual, thereby increasing the rate at which perspiration is

removed. Exposing textile 70 to a physical stimulus increases the texture of textile 70, thereby increasing the texture properties of apparel 10. Accordingly, textile 70 effectively adapts to changing perspiration levels of the individual in order to enhance the comfort of the individual wearing apparel 10.

Conclusion

[60] Based upon the above discussion, various textiles may be formed from yarns that transform dimensionally in the presence of a physical stimulus. The dimensional-transformation of the yarns modifies the structures of the textiles, thereby inducing a change in the properties of textiles. When incorporated into an article of apparel, the change in the properties of the textiles when exposed to the physical stimulus may be utilized to insulate the individual from specific environmental conditions or adapts to changing perspiration levels of the individual, for example. Accordingly, the present invention relates to textiles that effectively adapt to enhance the comfort of the individual wearing the apparel.

[61] The present invention is disclosed above and in the accompanying drawings with reference to a variety of embodiments. The purpose served by the disclosure, however, is to provide an example of the various features and concepts related to the invention, not to limit the scope of the invention. One skilled in the relevant art will recognize that numerous variations and modifications may be made to the embodiments described above without departing from the scope of the present invention, as defined by the appended claims.